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Six Sigma; As Applied in Quality Improvement for Injection Moulding Process

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Abstract

In recent couple of decades, it has been seen that the ratio of the required commodity changes and brings forth the requirement and necessity of quality improvement to be practiced more. Total quality for continuous improvement for reliable products is used by many industries for improvement of service and quality of product. In the previous decade, a novel based philosophy known as "Six Sigma" has been incorporated and very well established in many companies The goal of "Six Sigma" in any regime or technical aspect i.e. designing, manufacturing, processing, marketing or testing , improves effort to obtain a durable or long term defect rate of only 3.4 defective parts per million manufactured.

The Present study focuses on the quality improvement of one of the major defect in Plastic Injection Moulding of components. One of the main defect which is the causes of the rejection is "Black specks" (small dark particles on the surface of the opaque parts), on the appearance of the product. In order to study the problem a research has been carried out by studying the literature review on TQM, Six Sigma and other references for this analysis and research method.

The objectives of this paper is to identify the problem of Black specks, which reduces quality, due to defects in manufactured parts, and to suggest measures for the improvement in the Injection Moulding operation using Six-Sigma DMAIC methodology. This paper encompasses introduction and implementation of Six Sigma tools for removing the Black specks in the Injection Moulding process.

Keywords: Black specks, Six Sigma, Injection Moulding.

1. Introduction

This paper mainly focuses on Six Sigma quality philosophy that would be implemented in order to identify the problem during the Injection Moulding process. The "Six Sigma" Philosophy is used as it provides a step-by-step quality improvement methodology that uses statistical methods to quantify variation.

Being highly disciplined process Six Sigma helps to focus on developing and delivering very close to perfect solutions, products or services. Walter A. [1] introduces it in a different way. Six Sigma seek to reduce variation in the processes that lead to the defects [7, 12]. Six sigma now implemented and preferred for high progress in industries [2, 3, 4, 5]. Yang et. al. [9] presented model of TQM and Six Sima. Das. P. Studied delay rejection in procurement of material using Six Sigma. Raisinhani, Mahesh. S. [13] has mentioned Six Sigma tools to be widely applied now a days. Yang et al. (2009) Developed integral model of a business excellence system [19]. Xingxing et al.[18] (2008) and Chao-Ton [17] (2008) have discussed quality management techniques in the light of six sigma and Six Sigma projects.

The Present study focuses on the quality improvement of one of the major defect in Plastic Injection Moulding of components. One of the main defect which is the causes of the rejection is "Black specks" (small dark particles on the surface of the opaque parts), on the appearance of the product. In order to study the problem a research has been carried out by studying the literature review on TQM, Six Sigma and visiting a company.

The objectives of this paper is to identify the problem and root cause of Black specks, that occurs in the plastic products during the Injection Moulding process and which reduces quality, due to defects in manufactured parts, and to suggest measures for the improvement in the Injection Moulding operation using Six-Sigma DMAIC methodology. This paper encompasses introduction and implementation of Six Sigma tools for removing the Black specks in the Injection Moulding process. DMAIC stands for Define, Measure, Analyze, Improve and Control.

Fig. 1: black speck a defect in moulding process.

2. Injection Moulding Process

Injection Moulding is a manufacturing technique for making parts from thermoplastic material in production. Molten plastic is injected at high pressure into a mould, which is the inverse of the product's shape. Injection Moulding machines, also known as presses, hold the moulds in which the components are shaped. Presses are rated by tonnage, which expresses the amount of clamping force that the machine can generate.

The basic injection cycle is as follows: Mould closes - injection carriage forward injects plastic - metering - carriage retract - mould open - eject part. The moulds are closed shut by hydraulics or electric, and the heated plastic is forced by the pressure of the injection screw to take the shape of the mould. The water-cooling channels then assist in cooling the mould and the heated plastic solidifies into the part. Improper cooling can result in distorted moulding or one that is burnt. The cycles get completed when the mould opens and the part is ejected with the assistance of ejector pins within the mould. The resin, or raw material for injection moulding, is usually in pellet or granule form, and is melted by heat and shearing forces shortly before being injected into the mould. Resin pellets are poured into the feed hopper, a large open bottomed container, which feeds the granules down to the screw. The screw is rotated by a motor, feeding pellets up the screw's grooves. The depth of the screw flights decreases towards the end of the screw nearest the mould, compressing the heated plastic. As the screw rotates, the pellets are moved forward in the screw and they undergo extreme pressure and friction which generates most of the heat needed to melt the pellets. Heaters on either side of the screw assist in the heating and temperature control during the melting process.

The channels through which the plastic flows toward the chamber will also solidify, forming an attached frame. This frame is composed of the sprue, which is the main channel from the reservoir of molten resin, parallel with the direction of draw, and runners, which are perpendicular to the direction of draw, and are used to convey molten resin to the gate(s), or point(s) of injection. The sprue and runner system can be cut or twisted off and recycled, sometimes being granulated next to the mould machine. Some moulds are designed so that the part is automatically stripped through action of the mould.

3. Six Sigma Methodology: As Applied in Injection Moulding Process

The application of Six-Sigma methodology is a statistical analysis approach to quality management and hence the DMAIC method is used for improving the product quality during the Injection Moulding is as follows-

3.1 Define stage

3.1.1 Define the process

Before the process can be investigated, all circumstances have to be defined. Such circumstances are often described as SIPOC (Suppliers, Inputs, Process, Outputs and Customers)

3.1.2 Measure phase

In measure stage the defects per million opportunities is (DPMO) is calculated measure to help monitor progress towards the project goals. Customer expectations are defined to determine "out of specification" conditions.

3.1.3 Analyze stage

In analyze stage the root cause of the Black Specks defect is found out in the parts produced which is due to five major factors which are machine, environment, operator, method and the material.

Machines are one of the factors that must be given Black Specks consideration. The machine contributes a lot of possibilities to Black Specks rejection defect. Examples, without proper parameter setting, it will result to a carbonized screw. Aging machines also can lead to defects. Maintenance also plays an important part because, without maintenance the performance of machine will be affected and the desired output could not been gained.

When an operator does not have enough experience and practice, it is quite obvious that the operator produces more defects than the others. Defects might occur when jobs carried out without guidance of leader or without any instruction. Besides that, number of defect will increase when untrained operator or new operators are assigned to do the job. The work method is another major cause of the problem. It was found that the operator did not know the correct method set the machine and the parameters but only followed the instructions without knowing the correct method. As a result the operator can lead to black specks defect or other rejection.

Besides that, a material is an important medium in injection moulding process that contributes to some major defects. Examples, when material are contaminated with other foreign particles it will affect the properties of the part and at the same time it lead to major defects.

Some other factors are-

DAMAGED BARREL OR SCREW; A cracked injection cylinder or pitted screw is a cause of material hang-up and degradation. Eventually this degraded material breaks loose and enters the melt stream, appearing as specks

CONTAMINATION FROM LUBRICANTS: Excessive use of mould release will clog vents. The trapped air cannot be evacuated and burns. Also, grease that is used for lubricating cams, slides, ejector pins, etc., can seep into the mould cavity and contaminate the moulded part.

3.4 Improve stage

After collecting and analysing the data suggestion is recommended to reduce the defect. And the suggestions are to clean Barrel and use of cleaning agent for cleaning Screw and Barrel Screw.

MINIMIZE DOWNTIME AND REDUCE SCRAP; Special Material is cleaned on the first pass, minimizing machine downtime to maximize the productivity. This also reduces scrap so do not waste resin.

ECONOMICAL;- Only a small amount of material is needed to purge quickly and effectively. It has unlimited life.

SAFE TO USE;-Special material is non-chemical / no-hazardous and no abrasive. It does not cause wear on machines. It is safe for machines and operators and safe for disposal.

Based on the suggestion given, the rejection rate can be reduced and at the same time the sigma level can be improved.

3.1.5 Control stage

Control stage is another important stage before completing DMAIC methodologies. This stage will describe the step taken to control. One of the common types of quality tool used is the control chart.

Sigma level is computed as Z =0.8406+'{29.37-2.2211n(DPMO)} Where, DPMO= DPU/CTQ*10^6,

DPU= defect per unit =Rejection/Total pieces,

CTQ=critical to quality....through SIPCO (supplier, input, process, customer, output)

4. Result and Discussion

DMAIC method of Six Sigma was implemented considering four machines as shown in Table 1.

It shows that the highest rejection rate was identified in the month February (2012). Thus lowest sigma level i.e. 4.2356 was recorded for the month of February whereas the highest being 4.331 for May. The study is focussed for February. Further, Machine E02 has higher rejections due to black specks. Thus this machine will e required for analysing the root cause. A Brainstorming was carried on to discuss the problem. The root cause is given fig. 5.7

Table 1: Total output and sigma level.

Month	**Output**		**Machines**			**Total**	**DPMO**	**Sigma**
						Rej./month		
		E01	E02	E03	E04			
Feb.	149760	60	935	910	405	2310	3084	4.2356

Mar.	149760	53	937	908	367	2265	3024	4.2420
Apr.	149760	59	946	878	398	2281	3046	4.2397
May	149760	23	914	495	291	1723	2301	4.3301
Total	599040	195	3732	3191	1461	8579	-------	------

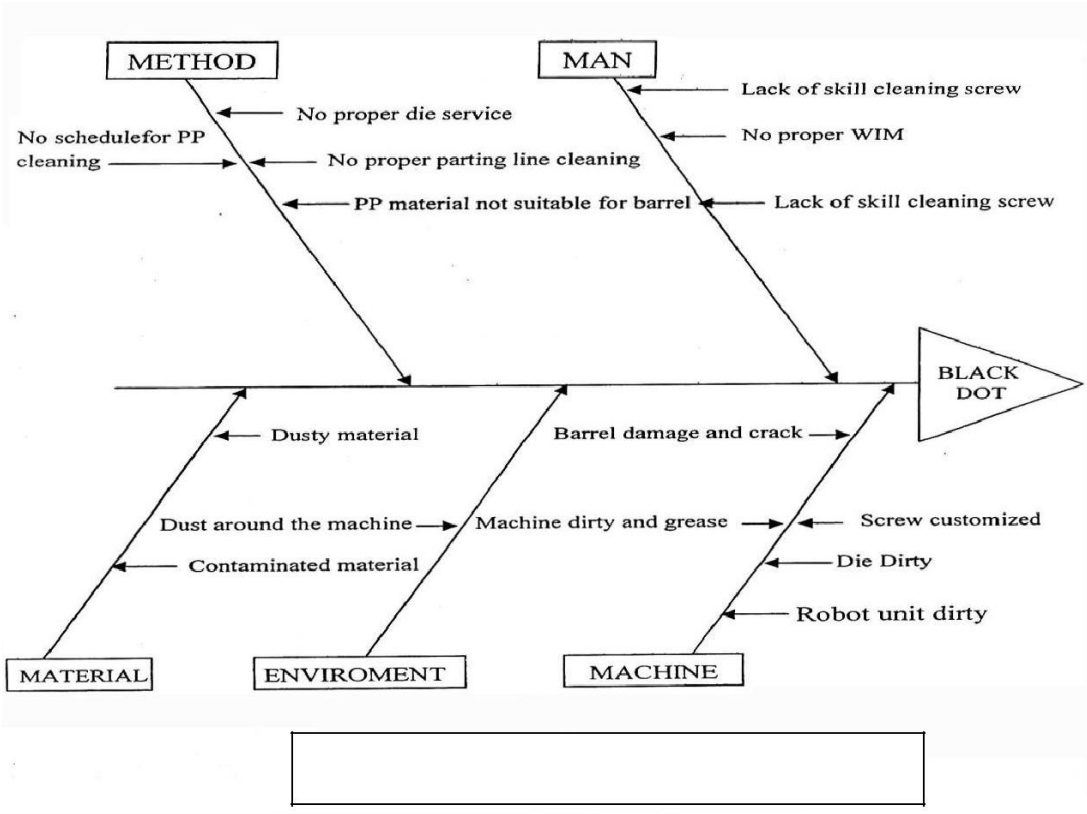

Fig. 2: Root cause analysis for lack specks.

5. Conclusion

Following suggestions are given a. clean Barrel and use cleaning agent for cleaning Screw and Barrel c. sand paper can also be used Most of the dirt was identified from the material which was carbonized because of overheated in the barrel. The overheated material will stick on the screw and will release slowly each time injection and caused for the black specks on the surface.

References

[1] Walter A. Shewhart-"Father of Statistical Control," Quality progress, January 1986, pp. 50-51

[2] Harry, M.J. and Schroeder, R. (2000) "Six sigma: The Break through - Management strategy revolutionizing the World's Top corporations." Doubleday, New York.

[3] Sanders, Doug; & Hild, Cheryl “A discussion of strategies for Six Sigma implementation” Quality Engineering. Vol.12, No.3, 303-309, 2000.
[4] Pande, Peter S.; Neuman, Robert P; & Cavanagh, Roland R. The six sigma say: sow GE, Motorola, and other top companies are honing their performance. McGraw-Hill -New York - 2000.
[5] Snee, R. D. “Dealing with the achilles´ hell of six sigma initiatives – Project selection is key to success” Quality Progress. March, 66-72, 2001.
[6] Coronado, R. B., & Antony, J., 2002, “Critical success factors for the successful implementation of six sigma projects in organizations,” The TQM Magazine, 14(2),92-99.
[7] Park, S. H., 2002, “Six sigma for productivity improvement: Korean business corporations,” Productivity Journal, 43(2), 173-183.
[8] Rajagopalan, R., Francis, M., & Suarez, W., 2004, “Developing novel catalysts with six sigma,” Research Technology Management, 48 (6), 377-391.
[9] Yang, Ching-Chow, (2004), “An integrated model of TQM and GE Six Sigma”, International Journal of Six Sigma and Competitive Advantage, Vol. 1 No. 1, pp. 97-111.
[10] Das, P., 2005, "Reduction in delay in procurement of materials using six sigma philosophy," Total Quality Management and Business Excellence, 16(5), 645656.
[11] John Gershenson, Pavnaskar, S.J., "Application of Value Stream Mapping to Lean Engineering," International Journal of Advanced Manufacturing Systems, Volume 8, No. 1, 2005-01-00.
[12] John Gershenson, Ye, X., Khadke, K., Lai, X., Guo, F. , "An Introduction to Product Family Evaluation Graphs," Proceedings of the 2005 ASME Design Engineering Technical Conferences -- 17th International Conference on Design Theory and Methodology, Long Beach, California, 2005-09-00.
[13] Raisinghani, Mahesh S. “Six Sigma: concepts, tools, and applications” Industrial Management & Data Systems.Vol.105,No.4,491-505,2005.
[14] Kim, Dong Suk (2006). A study on the service quality evaluation of University Library applying the LibQUAL+. Ewha Woman's University Department of Library and Information Science a master's thesis (writteninKorean).
[15] Kwak, Y. H., & Anbari, F. T., 2006, “Benefits, obstacles and future of six sigma approach,” Technovation, 26, 708-715.
[16] Lee, Seung Young, Yoon Jae Yong Kim, TaeHyum, Sohn, Soyoung, "A strategic Analysis of Korean Engineering Education based on two satisfaction scores", Journal of engineering Education, (April 2007).
[17] Chao-Ton, Su, Chia-Jen, & Chou, 2008, “A systematic methodology for the creation of Six Sigma projects: A case study of semiconductor foundry,” 34(4), 2693-2703.

[18] Xingxing, Zu, Lawrence, D., Fredendall, & Thomas, J., Douglas, 2008, “The evolving theory of quality management: The role of Six Sigma,” Journal of Operations Management, 26(5), 630 – 650.
[19] Yang, Ching-Chow, (2009). “Development of an integrated model of a business excellence system”, Total Quality Management & Business Excellence, 20 (9-10), 931-944.
[20] Chun-Chin, Wei, Gwo-Ji, Sheen, Cheng-Ting, Tai, & Kuo-Liang Lee, 2010, "Using Six Sigma to improve replenishment process in a direct selling company," Supply Chain Management: An International Journal, 15(1), – 9.